

studies on a moving average basis would be burdensome, and recommends using the moving average to update X-Factors based on the Historical Revenue Approach.<sup>383</sup> Some parties contend that this performance review has been a long and burdensome proceeding, and doubt that a moving average mechanism would be more burdensome.<sup>384</sup> USTA maintains that its TFP Review Plan simplifies calculating the moving average.<sup>385</sup> USTA also supports updating the moving average annually.<sup>386</sup>

86. Sprint maintains that neither AT&T's nor USTA's models are sufficiently developed to ensure reasonable results or to flow through unit cost reductions when updated annually, and recommends adopting a fixed interstate productivity offset for the next four years.<sup>387</sup> Sprint suggests that input prices are too volatile to give a five-year moving average a significant advantage over a fixed offset.<sup>388</sup> Sprint also opposes a moving average because it argues that Commission review of access rates will be more important as LECs and IXC's enter each others' markets.<sup>389</sup>

87. AT&T recommends conducting "performance reviews" annually, and conducting a complete performance review every three years, to ensure that incentive regulation is still functioning properly in light of subsequent developments in the telecommunications industry.<sup>390</sup> GSA would schedule the next performance review in 1998.<sup>391</sup> BellSouth maintains that there is no need to schedule another performance review now.<sup>392</sup> BellSouth expects the telecommunications industry to be competitive enough to warrant eliminating

---

<sup>383</sup> GSA Reply at 8-10.

<sup>384</sup> GTE Reply at 24-25. See also BellSouth Reply, Att. at 38.

<sup>385</sup> USTA Reply at 7-8.

<sup>386</sup> USTA Comments at 36.

<sup>387</sup> Sprint Comments at 19-20, 26-27. See also Ad Hoc Reply at 6.

<sup>388</sup> Sprint Comments at 20.

<sup>389</sup> Sprint Reply at 27.

<sup>390</sup> AT&T Comments at 46-48; AT&T Reply at 52 n.106. See also US West Reply at 36.

<sup>391</sup> GSA Reply at 12. GSA originally recommended scheduling the next performance review in 1997. GSA Comments at 9. GSA reasoned that the Commission might have to focus on implementing the 1996 Act in 1997, and so recommended scheduling the next performance review in 1998. GSA Reply at 12.

<sup>392</sup> BellSouth Comments at 33.

price caps before the next performance review might become necessary.<sup>393</sup> Alternatively, US West recommends scheduling a performance review in three to five years, to assess the level of competition.<sup>394</sup> US West maintains that a performance review is not necessary if we adopt its proposal to freeze the PCIs at their current levels.<sup>395</sup>

## VI. COMMON LINE ISSUES

### B. Reliance on Forecasted Data

88. Southwestern Bell recommends continuing to use forecasted data if we retain a separate common line formula, because historical data would be based in part on "Part 69 revenue requirement calculations."<sup>396</sup> US West and USTA recommend using historical data, to make the common line formula consistent with the price cap formula for the other baskets.<sup>397</sup> MCI does not oppose basing the hypothetical EUCL per minute charges on historical data, as long as the CCL rates continue to be based on the proposed EUCL rates.<sup>398</sup> AT&T recommends basing carrier common line rates on historical growth rates of interstate access services for the previous eight years, extrapolated into the prospective price cap period by a linear trend.<sup>399</sup> Pacific opposes this recommendation.<sup>400</sup>

## VII. EXOGENOUS COST ISSUES

89. MCI argues that the only cost changes warranting exogenous treatment are changes in separations rules and rules governing the allocation of costs between the regulated and non-regulated accounts. According to MCI, firms facing competition must determine how to face cost changes without changing their prices, and price cap regulation should reflect this.<sup>401</sup> MCI also argues that this rule change would conserve the administrative resources consumed by

---

<sup>393</sup> BellSouth Comments at 29, 44.

<sup>394</sup> US West Comments at 28. See also NYNEX Comments at 23.

<sup>395</sup> US West Reply at 36.

<sup>396</sup> Southwestern Bell Comments at 37-38.

<sup>397</sup> US West Comments at 26-27; USTA Comments at 45-46.

<sup>398</sup> MCI Comments at 23-24.

<sup>399</sup> AT&T Comments, App. B at 46.

<sup>400</sup> Pacific Reply at 15.

<sup>401</sup> MCI Comments at 25; MCI Reply at 17-18.

determining whether to treat a particular cost change exogenously or endogenously.<sup>402</sup> TRA supports MCI's recommendation.<sup>403</sup> A number of commenters oppose MCI's exogenous cost suggestion.<sup>404</sup> USTA notes that the Commission created a procedure in the LEC Price Cap Performance Review for considering whether to treat a cost change exogenously. Because of this, USTA maintains that restricting exogenous cost treatment as MCI proposes is not necessary.<sup>405</sup> USTA and Pacific reply that it would be unreasonable to grant exogenous treatment to some cost changes beyond the carriers' control and not otherwise reflected in the price cap formula, but not other cost changes.<sup>406</sup> According to US West, MCI assumes that prices remain static in competitive markets, and contends that this assumption is unreasonable.<sup>407</sup> If the Commission does not adopt its TFP-based X-Factor method, NYNEX recommends retaining the existing exogenous cost rules.<sup>408</sup>

---

<sup>402</sup> MCI Comments at 25-26; MCI Reply at 17-18.

<sup>403</sup> TRA Reply at 9-10.

<sup>404</sup> USTA Comments at 46-47; Sprint Comments at 14-15; US West Reply at 34-35; Frontier Reply at 6; USTA Reply at 29-30.

<sup>405</sup> USTA Comments at 46-47, citing First Report and Order, 10 FCC Rcd at 9099 (para. 316).

<sup>406</sup> USTA Reply at 29-30; Pacific Reply at 16-17.

<sup>407</sup> US West Reply at 35.

<sup>408</sup> NYNEX Reply at 30.

**APPENDIX C****AMENDMENTS TO THE CODE OF FEDERAL REGULATIONS****PART 61 -- TARIFFS**

1. The authority citation continues to read as follows:

Authority: Secs. 1, 4(i), 4(j), 201-205, and 403 of the Communications Act of 1934, as amended; 47 U.S.C. 151, 154(i), 154(j), 201-205, and 403, unless otherwise noted.

2. Section 61.45(b)(1) and (2) are amended to read as follows:

**§ 61.45 Adjustments to the PCI for Local Exchange Carriers**

\* \* \* \* \*

(b) \* \* \*

(1) Notwithstanding the value of X defined in § 61.44(b), the X value applicable to the baskets specified in § 61.42(d)(2), (3), and (6) shall be 6.5%.

(2) For the basket specified in § 61.42(d)(4), the value of X, for all local exchange carriers subject to price cap regulation, shall be 3.0%.

3. Section 61.45(c) is amended by revising paragraph (c)(1) and adding new language at the end of paragraph (c)(2) to read as follows:

**§ 61.45 Adjustments to the PCI for Local Exchange Carriers**

\* \* \* \* \*

(c)(1) Subject to paragraphs (c)(2) and (e) of this section, adjustments to local exchange carrier PCIs for the basket designated in § 61.42(d)(1) shall be made pursuant to the following formula:

\* \* \*

X = productivity factor of 6.5%,

\* \* \*

(2) \* \* \*

For the purposes of this paragraph, and notwithstanding the value of X defined in § 61.44(b), the X value applicable to the basket specified in § 61.42(d)(1), shall be 6.5%.

4. Section 61.45(d)(2) is redesignated as 61.45(d)(2)(i), and new subparagraph (d)(2)(ii) is added to read as follows:

**§ 61.45 Adjustments to the PCI for Local Exchange Carriers**

\* \* \* \* \*

(d) \* \* \*

(2) \* \* \*

(ii) Local exchange carriers specified in § 61.41(a)(2) or (a)(3) shall not be subject to the sharing mechanism set forth in the Commission's Second Report and Order in Common Carrier Docket No. 87-313, FCC 90-314, adopted September 19, 1990, with respect to earnings accruing on or after July 1, 1997. This rule has no effect on any sharing obligation of any local exchange carrier relating to earnings accrued before July 1, 1997.

5. Section 61.45(h) is deleted and reserved.

## Appendix D

### Estimation of TFP Under FCC Rules

### FCC Synthesis

C. Anthony Bush  
and  
Lori Huthoefer

## I. INTRODUCTION

In this Appendix, we present the methodology used by the FCC's staff to estimate LEC Total Factor Productivity ("TFP") and input prices, and to calculate the LEC TFP and input price differentials used in the FCC's LEC price cap X-factor.<sup>1</sup> We calculate TFP based on the LEC regulated books of account, excluding miscellaneous services. Thus, our measure of total factor productivity is an approximation of the productivity of all LEC activities. Our calculations are for the period 1985 through 1995.

We largely base our calculations on a simplification and correction of AT&T's implementation of the Fisher Ideal Index methodology, but incorporate certain aspects of USTA's methodology as well.<sup>2</sup> Our TFP estimates embody what we believe to be the best practices proposed by the parties in this proceeding. For example, we used a modification of USTA's method of calculating materials expense. We also employed the perpetual inventory model proposed by USTA, although our implementation differed from that of USTA. We chose to pair end user charges with access lines, as did USTA, instead of with CCL minutes, as did AT&T. As described below, we adjusted pre-1988 data for the effects of 1988 changes in accounting rules using a methodology consistent with that of USTA's Christensen.

Our study is based on data publicly available from the FCC, BEA, and BLS, and on Christensen's data on capital/expense shifts. All these data are part of the public record in this proceeding. Our data are for the seven Regional Bell Operating Companies (RBOCs). Our 1985 base year benchmark capital stock is the net book accounting value of total plant in service. The weights in our input index are based on the shares of total factor payments of capital, labor, and material. Capital's share of total factor payments is based upon the authorized rate of return, actual earnings in excess of that rate of return, and the authorized rates for depreciation.

## II. INDICES USED

We constructed our input and output indices using the the Fisher Ideal Index. This index is the geometric average of the Laspeyres Index and the Paasche Index. For two periods ( $t = 0, 1$ ), the Fisher Ideal Quantity Index can be written as

---

<sup>1</sup> This paper benefitted from discussions with FCC Consultant Dr. P.J. Dhrymes, and from considerable assistance by FCC Staff members Jay Atkinson, Christopher Barnekov and Brad Wimmer.

$$I_{o,1} = \left[ \left( \frac{\sum_{j=1}^n P_{o,j} Q_{1,j}}{\sum_{j=1}^n P_{o,j} Q_{o,j}} \right) \times \left( \frac{\sum_{j=1}^n P_{1,j} Q_{1,j}}{\sum_{j=1}^n P_{1,j} Q_{o,j}} \right) \right]^{\frac{1}{2}} \quad (1)$$

where  $P_{t,j}$  and  $Q_{t,j}$  are the price and quantity of good  $j$ ,  $j = 1, \dots, n$ , at time  $t$ ,  $t=0,1$ . In addition, it can be shown that the Fisher Ideal Quantity Index can be written as

$$I_{o,1} = \left[ \left( \sum_{j=1}^n w_{o,j} \frac{Q_{1,j}}{Q_{o,j}} \right) \times \frac{1}{\left( \sum_{j=1}^n w_{1,j} \frac{Q_{o,j}}{Q_{1,j}} \right)} \right]^{\frac{1}{2}} \quad (2),$$

where  $w_{t,j}$  is commodity  $j$ 's share of revenue at time  $t$ ,  $t=0,1$ .<sup>2</sup> If periods 0 and 1 are adjacent periods, Equation 2 is referred to as a Fisher Ideal Quantity Relative. Defining

$I_{o,o}$  to be 1, a chained Fisher Ideal Quantity Index between periods 0 and  $t$  is the product of each of the Fisher Ideal Quantity Relatives between 0 and  $t$ :

$$I_{o,t} = I_{o,o} \times I_{o,1} \times I_{1,2} \times \dots \times I_{t-1,t}$$

Both our output and input indices are chained Fisher Ideal Quantity Indexes.

We measure input prices by calculating a Fisher Ideal Price Relative, which compares aggregate input price levels to those for the previous period. The Fisher Ideal Price Relative is analogous to the Fisher Ideal Quantity Relative, and can be written as

$$I_{o,1}^p = \left[ \left( \sum_{j=1}^n w_{o,j} \frac{P_{1,j}}{P_{o,j}} \right) \times \frac{1}{\left( \sum_{j=1}^n w_{1,j} \frac{P_{o,j}}{P_{1,j}} \right)} \right]^{\frac{1}{2}} \quad (3)$$

<sup>2</sup> Kali S. Banerjee, *Cost of Living Index Numbers* (New York: Marcel Dekker, Inc., 1975), pp.3-20.

In this case, the  $w_{t,j}$  are shares of total payments to factors. Using this price index relative, the input price index is a chained Fisher Ideal Price Index.

### III. CALCULATION OF OUTPUT INDICES

#### A. Data Sources

Our output indices are based on actual quantity measures from two Commission publications. Basic local service revenue, end user revenue, switched access revenue, special access revenue, state access revenue, and total long distance network revenue are taken from the Commission's *Statistics of Communications Common Carriers* ("SOCC") for 1985 through 1995. We also took the number of local calls, special access lines, business access lines, residential access lines, and public access lines from SOCC. We measure state toll and intrastate access volumes by state dial equipment minutes, taken from the FCC Monitoring Reports.<sup>3</sup> Interstate switched access minutes are from the same Monitoring Reports.

#### B. Output Category Quantity Indices and Revenue Shares

We constructed an interstate quantity index to measure growth of interstate services. We constructed this index using the following three physical quantities: access lines, interstate switched access minutes, and interstate special access lines. We measured access lines by the sum of business, public, and residential access lines.

Service  $j$ 's share of total revenue is

$$w_{t,j} = \frac{R_{t,j}}{\left( \sum_{j=1}^n R_{t,j} \right)} \quad (4),$$

where  $R_{t,j}$  is the revenue from interstate service  $j$  at time  $t$ .

We weighted growth in access lines by the End User Common Line revenue share of total interstate revenues. Growth in switched access minutes was weighted by the switched

---

<sup>3</sup> In 1987 a Joint Board created a monitoring report to collect a variety of data, including dial equipment minutes (DEMs). We rely on the May 1993 through May 1996 Monitoring Reports for the intrastate DEMs and interstate switched access minutes (these reports include data for the prior years). See Amendment of Part 36 of the Commission's Rules and Establishment of a Joint Board, Establishment of a Program to Monitor the Impact of Joint Board Decisions, CC Docket Nos. 80-286 and 87-339, 7 FCC Rcd 4541.

access revenue share, and growth in special access lines was weighted by the special access revenue share. We then used equation 2 to construct Fisher Ideal Quantity Index Relatives. The composite Fisher Ideal Interstate Quantity Index is derived by chaining the Fisher Interstate index relatives.

We used a completely analogous procedure to construct revenue shares and quantity indices for total local service and state toll/access service. State toll/access revenues are total toll service revenues plus intrastate access revenues. The physical units associated with total local service are the number of local calls. For state toll/access service, the physical units are state dial equipment minutes from the Monitoring Report.

### C. Total Output Index

We constructed the total company output index using the service quantity indices and revenue shares calculated as described above (for local service, intrastate toll/access, and interstate). We calculated interstate share of total revenue using the sum of end user revenue, switched access revenue (formerly called "carrier's carrier facilities revenues"), and interstate special access revenue. We then used Equation 2 to construct Fisher Ideal Quantity Index Relatives. Our total company output index is a chained Fisher Ideal Quantity Index.

## IV. INPUTS

### A. Labor

Our measure of the quantity and the cost of labor is based on annual accounting data for the number of employees and total labor compensation reported by the LECs in their ARMIS reports to the FCC. Our labor price index is created by dividing average compensation per employee for each year by the 1985 average compensation per employee. We let  $TCOMP_t$  denote total compensation to labor in year  $t$  and  $NEM_t$  denote the number of employees in year  $t$ . Compensation per employee,  $CPEM_t$ , is  $CPEM_t = \frac{TCOMP_t}{NEM_t}$ . The components of the labor price index are

$$1, \frac{CPEM_{1986}}{CPEM_{1985}}, \dots, \frac{CPEM_{1995}}{CPEM_{1985}}.$$

## B. Materials

Our materials quantities are derived by dividing materials expense by a materials price index. Materials expenses for 1985 through 1987 must be adjusted for two accounting changes that became effective in 1988. First, beginning in 1988 all expenses from nonregulated services that had joint and common costs with regulated services were reported in operating expenses. Second, certain plant investments that formerly were capitalized began to be expensed in the year they were incurred. Accordingly we adjusted 1985 through 1987 expenses upward to put them on a basis comparable to the accounting expense recorded from 1988 onward.

Our adjustments of materials expense for 1985 through 1987 follow the work of USTA's Christensen. No party objected to or replicated Christensen's method of adjusting materials expense.<sup>4</sup> Christensen's adjustment is based on data from a nine-company sample. We calculated our adjustment factor by dividing the sum of annual reported operating expense plus Christensen's adjustment by reported operating expenses for the years 1985-1987. These percentages are used to adjust 1985 through 1987 operating expenses of the RBOCs.

Mathematically, we can express our adjustment as follows: Let  $OPREXP_t$  denote the composite (nine-company) operating expense in year  $t$  from the Revised Christensen Study (1995). We let  $ADDEXP_t$  be the additional materials expense resulting from both the regulated/nonregulated change and the capital/expense shift (the data we used are shown in Chart D8a). The adjustment to RBOC operating expense is

$$RBOCEXP_t^{Adj} = \left( \frac{OPREXP_t + ADDEXP_t}{OPREXP_t} \right) \times RBOCEXP_t, \quad t=1985, 1986, 1987$$

where  $RBOCEXP_t$  is the unadjusted operating expense of the RBOCs at time  $t$ .

Materials expense is total adjusted operating expense minus the sum of total labor compensation, depreciation, and amortization expense.

---

<sup>4</sup> USTA's updated study submitted in the Access Charge Reform, Notice of Proposed Rulemaking, CC Docket No. 96-262, began with 1988 and thus needed no adjustment.

$$MATERIALS_t = RBOCEXP_t^{Adj} - (Depreciation_t + Amortization_t) - TCOMP_t .$$

We deflate materials expense to derive materials quantities using the materials price index developed by AT&T's Norsworthy and placed in the record by AT&T.<sup>5</sup> This index is based on those categories of expenditures from the BLS National Input/Output Tables that are more narrowly focused on materials purchases of communications industries than is the economy-wide GDP-PI measure of inflation. We replicated the index using the same BLS data AT&T used in an ex parte filing received on April 11, 1996.<sup>6</sup> AT&T's materials price index is a Tornquist index calculation, where the logarithmic percentage changes are replaced by arithmetic percentage changes.<sup>7</sup>

### C. Capital

We follow Ad Hoc, USTA's Christensen, and AT&T's Norsworthy in measuring capital based on the Perpetual Inventory Model. We use the Perpetual Inventory Model to remove embedded inflation that would distort the measurement of capital. We examine only one asset class because the record shows that the number of asset classes does not significantly affect estimated growth in TFP. Our application of the Perpetual Inventory Model relies on Commission depreciation rates, as do those of Ad Hoc and AT&T.

#### PERPETUAL INVENTORY MODEL

For a single asset class, the Perpetual Inventory Model is written as

$$K_t = (1 - \delta) \times K_{t-1} + I_t \quad (5)$$

where  $K_t$  is the capital stock quantity at the of end year  $t$  and  $\delta$  is the average depreciation rate (calculated as discussed below). Investment, *i.e.* capital additions, measured in constant (inflation-adjusted) dollars is  $I_t$ . Following Christensen, Norsworthy, and Ad Hoc, we use

---

<sup>5</sup> Comments of AT&T, Price Cap Performance Review, CC Docket 94-1, Jan. 11, 1996, Appendix A: Statement of Dr. John R. Norsworthy.

<sup>6</sup> AT&T Ex Parte Letter of April 11, 1996.

<sup>7</sup> The most recent BLS Input/Output Table was for 1993. We determined the 1994 and 1995 materials price index data points by extrapolating based on average growth in prior years.

book value of plant as the basis for calculating the benchmark (i.e. initial level) capital stock. In order to calculate constant dollar investment, we use chained Fisher asset prices from BEA to deflate capital additions.

#### *CAPITAL ADDITION ADJUSTMENTS*

Our benchmark capital stock is based on the end of year 1985 book value. Because of the 1988 capital/expense shift, we must adjust both end of year 1985 total plant in service less accumulated depreciation and 1985-1987 capital additions. We use Christensen's capital/expense shift factor to reduce capital additions for 1985 through 1987. For  $t = 1985, 1986, 1987$ , the adjusted capital additions, denoted  $CA_t^{Adj}$ , are

$$CA_t^{Adj} = CA_t \times F$$

where  $CA_t$  is the unadjusted capital additions and where  $F = 0.888$  (taken from the Revised Christensen Study, 1995). We obtained unadjusted capital additions from FCC Form M.

#### *ASSET PRICES*

Since we have a single asset class, we construct a single composite asset price index. Following Ad Hoc, AT&T, and USTA, we obtained BEA asset prices. We obtained prices for three BEA asset categories: Communications Equipment (BEA's Table 7.8: Chained-Type Price indexes for Private Purchases of Producers' Durable Equipment by Type, Line 7); Telecommunication Structures (BEA's Table 7.7: Chained-Type Price Indexes for Private Purchases of Structure by Type, Line 12); and a composite asset price for Producer Durables (BEA's Table 7.1, Line 39). We grouped our capital additions data into categories that correspond with the BEA asset categories, and calculated each category's share. (The capital/expense shift adjustment factor discussed above has no effect on the shares because it is multiplicative in nature and applies equally to all categories.)

For our single asset, the Fisher Ideal Price Index Relative is

$$I_{0,1}^A = \left[ \left( \sum_{j=1}^3 w_{0,j}^A \frac{P_{1,j}^A}{P_{0,j}^A} \right) \times \frac{1}{\left( \sum_{j=1}^3 w_{1,j}^A \frac{P_{0,j}^A}{P_{1,j}^A} \right)} \right]^{\frac{1}{2}} \quad (6),$$

where  $w_{t,j}^A$  is category  $j$ 's share of the value of total capital additions. The price of category  $j$  at time  $t$ ,  $t = 0, 1$ , is  $P_{t,j}^A$ . From these relatives, we form a chained Fisher Price Index for our single asset. This price index is used to deflate adjusted capital additions in the Perpetual Inventory Model.

#### *BENCHMARK CAPITAL STOCK*

Our benchmark capital stock is derived using the FCC accounting relationship

$$TPIS.BOY_t + CA_t - Retires_t = TPIS.EOY_t$$

Beginning of year Total Plant in Service is  $TPIS.BOY_t$  in period  $t$ , and end of year TPIS is  $TPIS.EOY_t$ .

We incorporated adjusted capital additions, which results in a revised

$$TPIS.EOY_t, t=1985, 1986, 1987.$$

We then obtain our benchmark capital stock by subtracting accumulated depreciation from revised 1985 TPIS.

As is standard practice in TFP studies, we do not include land when forming the benchmark capital stock. We do not apply USTA's economic stock adjustment factors because such factors assume asset lives that are inconsistent with Commission depreciation rates.

#### *DEPRECIATION RATES*

Each Perpetual Inventory Model in this record used depreciation rates that are constant over time. In Christensen's model depreciation rates vary by asset class, but for each asset class the depreciation rate does not vary over time. The revised version of AT&T's Performance-Based Model relies on estimates of Commission depreciation rates for six asset

classes, but for each asset class the depreciation rate is constant and obtained by averaging over time. Simplifying Norsworthy's approach, we calculated the Commission's time-invariant depreciation rate for our single asset class.

In year  $t$ , we calculated the average depreciation rate as

$$\delta_t = \frac{DEPR.ACRLS_t}{((TPIS.BOY_t + TPIS.EOY_t) / 2)}$$

where  $\delta_t$  is the composite depreciation rate in period  $t$ . In year  $t$ , the depreciation accruals are  $DEPR.ACRLS_t$ . Our constant depreciation rate is

$$\delta = \frac{(\sum_{t=1}^{11} \delta_t)}{11},$$

which is the average depreciation rate for the period 1985 through 1995.

#### *SERVICE FLOWS - CAPITAL INPUT QUANTITIES*

Following Christensen, we compute a quantity index of capital services. At time  $t$ , the capital input quantity is denoted

*Capital Input Quantity<sub>t</sub>*, and

$$Capital\ Input\ Quantity_t = \frac{Capital\ Stock\ Quantity_{t-1}}{Capital\ Stock\ Quantity_{t=1984}}, \quad t=85', \dots, 95'$$

The 1984 capital stock is calculated from the 1985 benchmark, as

$$Capital\ Stock\ Quantity_{84} = \frac{Capital\ Stock\ Quantity_{85} - Investment_{85}}{1 - \delta},$$

$$\text{where } Investment_{85} = \frac{Current\ Dollar\ Investment_{85}}{Asset\ Price\ Index_{85}},$$

This calculation follows the practice of Christensen in his Revised Study (1995) and AT&T's April 16, 1997 Study.

#### D. AGGREGATE INPUT INDEX

Having constructed input indices for all three factors of production, we use equation 2 to aggregate them into an aggregate input index. In order to use equation 2, we need each factor's share of total costs. The payment to labor is total compensation, the payment to materials is materials expense, and following AT&T, the payment to capital is property income. At time  $t$ , property income is denoted  $PINC_t$ , and is calculated as

$$PINC_t = Revenue_t - MATERIALS_t - TCOMP_t$$

The sum of total payments to each of the factors of production is denoted by  $TPAY$ . For each factor of production, we calculate shares of  $TPAY$  as follows. At time  $t$ , labor's share is

$$w_{t,1}^* = \frac{TCOMP_t}{TPAY_t} \quad . \quad \text{Materials' share is } w_{t,2}^* = \frac{MATERIALS_t}{TPAY_t} \quad . \quad \text{Capital's share is}$$

$$w_{t,3}^* = \frac{PINC_t}{TPAY_t} \quad . \quad \text{Our aggregate input index relative is}$$

$$I_{o,1}^* = \left[ \left( \sum_{j=1}^3 w_{o,j}^* \frac{Q_{1,j}^*}{Q_{o,j}^*} \right) \times \frac{1}{\left( \sum_{j=1}^3 w_{1,j}^* \frac{Q_{o,j}^*}{Q_{1,j}^*} \right)} \right]^{\frac{1}{2}} \quad (7) ,$$

For labor,  $Q_{t,j=1}^*$  is the number of employees, and for materials,  $Q_{t,j=2}^*$  is deflated materials expense. For capital,  $Q_{t,j=3}^*$  is the capital input quantity. The aggregate input index is a chained Fisher Ideal quantity index.

#### V. MEASURED TFP

We calculated the percentage change in measured TFP based on our total output and total input chained-linked Fisher Ideal Indices. For a given year, the percentage change in TFP is simply the percentage change in output minus the percentage change in input, where all percentage changes are logarithmic percentage changes. We report our FCC synthesis percentage changes in TFP in Chart D1.

To obtain the TFP Differential, we subtracted TFP growth in the general economy from LEC TFP growth. We used the BLS estimate of Nonfarm Business Sector Multifactor Productivity<sup>8</sup> as our measure of general TFP growth. The most recent published data in this series is for 1994. We estimated the 1995 growth as the average of the five most recent years.

## VI. INPUT PRICE DIFFERENTIALS

Our X-Factor includes both the difference between LEC TFP and TFP for the entire economy and an Input Price Differential. We calculated a RBOC input price index using our labor price index, AT&T's materials price index, and a capital price index based on the methodology proposed by AT&T. With only one asset, the rental price is property income divided by the real capital stock used in that period, i.e., the capital stock quantity.<sup>9</sup> The resulting data is normalized, with 1985 as the base year.

Let  $v_t$  be the rental price of capital in period  $t$ .

$$v_t = \frac{PINC_t}{K_{t-1}}$$

The price index for capital is  $P_{t,3}^*$ ,  $t = '85, \dots, '94$  which is

$$1, \frac{v_{86}}{v_{85}}, \dots, \frac{v_{95}}{v_{85}}$$

<sup>8</sup> Bureau of Labor Statistics, Office of Productivity and Technology, Net Multifactor Productivity and Costs, Nonfarm Business Sector (Excluding Government Enterprises), Table NFB4a, January 17, 1996.

<sup>9</sup> Calculating an implicit price (rental) of capital by dividing returns to capital by the real capital stock, is undertaken by Dhrymes (1990). See Phoebus J. Dhrymes, "The Structure of Production Technology: Evidence from the LED Sample I," in *Bureau of Census 1990 Annual Research Conference - Proceedings*, U.S. Department of Commerce, Bureau of the Census, 1990.

Using our factor shares of total payments and equation 3, the Fisher Ideal Input price relative is

$$I_{o,1}^{**} = \left[ \left( \sum_{j=1}^3 w_{o,j}^* \frac{P_{1,j}^*}{P_{o,j}^*} \right) \times \frac{1}{\left( \sum_{j=1}^3 w_{1,j}^* \frac{P_{o,j}^*}{P_{1,j}^*} \right)} \right]^{\frac{1}{2}} \quad (8)$$

The price index of factor  $j$ ,  $j = 1, 2, 3$ , is  $P_{t,j}^*$ . From these relatives, we derive our chained Fisher Ideal Input Price Index.

Our Input Price Differential is obtained by subtracting growth in our Input Price Index from growth in general input prices. As our measure of general input price growth, we used the BLS Nonfarm Business Sector Input Price Index. This is from the same source as, and is developed in conjunction with, BLS's measure of general TFP growth. Again, the most recent published data is for 1994 and we estimated 1995 input price growth as the average of the five prior years.

### ***Results***

The attached charts present our TFP and Input Price Differential calculations, and the development of our underlying input, output, and input price indices.

## FCC Staff Estimates

**Chart D1: Components of FCC LEC Price Cap X-Factor [Excluding CPD]**

Year	Input Price Growth Rates			Total Factor Productivity Growth Rates			LEC
	Total	U.S. Nonfarm	Differential	Total	U.S. Nonfarm	Differential	Price/Productivity
	RBOCs	Business Sector		RBOCs	Business Sector		Differential
	A	B	C = B - A	D	E	F = D - E	G = C + F
1986	4.94%	2.81%	-2.13%	2.58%	0.92%	1.66%	-0.5%
1987	0.56%	2.53%	1.97%	2.97%	-0.02%	2.99%	5.0%
1988	-1.58%	3.73%	5.31%	0.12%	0.46%	-0.33%	5.0%
1989	-2.36%	3.04%	5.40%	1.94%	-0.55%	2.50%	7.9%
1990	1.88%	3.31%	1.43%	6.85%	-0.47%	7.33%	8.8%
1991	-0.85%	2.06%	2.91%	2.03%	-0.89%	2.92%	5.8%
1992	2.67%	2.88%	0.21%	4.32%	1.10%	3.21%	3.4%
1993	2.27%	3.72%	1.44%	3.81%	0.55%	3.26%	4.7%
1994	-0.19%	3.50%	3.69%	2.21%	0.50%	1.71%	5.4%
1995*	1.31%	3.09%	1.78%	5.20%	0.16%	5.04%	6.8%
Averages							
[1986-94]	0.82%	3.06%	2.25%	2.98%	0.18%	2.80%	5.1%
[1986-95]	0.87%	3.07%	2.20%	3.20%	0.17%	3.03%	5.2%
[1987-95]	0.41%	3.10%	2.68%	3.27%	0.09%	3.18%	5.9%
[1988-95]	0.39%	3.17%	2.77%	3.31%	0.11%	3.20%	6.0%
[1989-95]	0.68%	3.09%	2.41%	3.77%	0.06%	3.71%	6.1%
[1990-95]	1.18%	3.09%	1.91%	4.07%	0.16%	3.91%	5.8%
[1991-95]	1.04%	3.05%	2.01%	3.51%	0.28%	3.23%	5.2%

\*Columns B and E for 1995 are estimated, based on the average of 1990-1994.

## FCC Staff Estimates

**Chart D2: RBOC Interstate Revenues**

	End User	Interstate Switched Access	Special Access	Total Interstate
	A	B	C	D = A + B + C
Year				
1985	\$1,499,413,893	\$10,906,203,190	\$1,960,688,644	\$14,366,305,727
1986	\$2,400,475,814	\$10,484,265,170	\$2,574,800,716	\$15,459,541,700
1987	\$3,090,639,929	\$9,611,996,187	\$2,657,677,439	\$15,360,313,555
1988	\$3,604,221,000	\$9,662,529,000	\$2,539,698,000	\$15,806,448,000
1989	\$4,398,692,000	\$9,092,575,000	\$2,253,922,000	\$15,745,189,000
1990	\$4,679,142,000	\$8,595,750,000	\$2,209,064,000	\$15,483,956,000
1991	\$4,828,177,000	\$8,514,130,000	\$2,119,037,000	\$15,461,344,000
1992	\$4,963,262,000	\$8,650,880,000	\$2,153,565,000	\$15,767,707,000
1993	\$5,244,094,000	\$8,999,065,000	\$2,097,997,000	\$16,341,156,000
1994	\$5,589,662,000	\$9,293,783,000	\$2,217,125,000	\$17,100,570,000
1995	\$5,770,285,000	\$9,332,869,000	\$2,529,667,000	\$17,632,821,000

**Chart D3: RBOC REVENUES (Excluding Miscellaneous Services)**

	Local Service	Intrastate Toll and Intrastate Access	Interstate	Total
	A	B	C	D = A + B + C
Year				
1985	\$26,960,554,164	\$13,047,095,682	\$14,366,305,727	\$54,373,955,573
1986	\$28,626,174,049	\$13,538,946,795	\$15,459,541,700	\$57,624,662,544
1987	\$29,150,842,991	\$14,166,723,124	\$15,360,313,555	\$58,677,879,670
1988	\$29,226,988,000	\$14,994,975,000	\$15,806,448,000	\$60,028,411,000
1989	\$29,973,157,000	\$14,868,219,000	\$15,745,189,000	\$60,586,565,000
1990	\$30,699,085,000	\$15,014,729,000	\$15,483,956,000	\$61,197,770,000
1991	\$32,059,008,000	\$14,522,276,000	\$15,461,344,000	\$62,042,628,000
1992	\$33,359,990,000	\$14,225,181,000	\$15,767,707,000	\$63,352,878,000
1993	\$34,598,957,000	\$14,496,831,000	\$16,341,156,000	\$65,436,944,000
1994	\$35,758,637,000	\$14,355,983,000	\$17,100,570,000	\$67,215,190,000
1995	\$37,684,860,000	\$13,123,225,000	\$17,632,821,000	\$68,440,906,000

## FCC Staff Estimates

**Chart D4: Calculation of Fisher Ideal Index for Interstate Output**

Year	Revenue Shares			Quantities			Output Indices			Interstate Output Quantity Index	Growth
	End User	Interstate Switched Access	Special Access	Access Lines	Switched Access Minutes	Special Access Lines	Laspeyres	Paasche	Fisher Relative		
							A	B	$C=(A*B)^{0.5}$		
1985	10.44%	75.92%	13.65%	92,671,959	156,853,820,000	1,230,590	1.000000	1.000000	1.000000	1.000000	
1986	15.53%	67.82%	16.66%	95,333,884	157,302,701,000	1,664,101	1.053249	1.052253	1.052751	1.052751	5.14%
1987	20.12%	62.58%	17.30%	98,228,585	173,154,171,000	1,764,445	1.083098	1.078813	1.080953	1.137975	7.78%
1988	22.80%	61.13%	16.07%	98,270,787	187,663,836,000	2,701,817	1.144443	1.114960	1.129605	1.285462	12.19%
1989	27.94%	57.75%	14.31%	101,190,050	210,406,134,000	2,448,090	1.065766	1.058920	1.062338	1.365595	6.05%
1990	30.22%	55.51%	14.27%	103,857,988	231,960,296,000	3,518,005	1.129086	1.114500	1.121769	1.531882	11.49%
1991	31.23%	55.07%	13.71%	107,383,807	246,710,182,000	5,151,699	1.111811	1.094856	1.103301	1.690127	9.83%
1992	31.48%	54.86%	13.66%	108,938,065	262,187,655,000	6,033,139	1.062516	1.060258	1.061386	1.793878	5.96%
1993	32.09%	55.07%	12.84%	112,196,681	278,173,161,000	10,153,615	1.136148	1.102619	1.119258	2.007812	11.27%
1994	32.69%	54.35%	12.97%	115,264,861	298,342,017,323	13,824,365	1.095119	1.086800	1.090952	2.190425	8.71%
1995	32.72%	52.93%	14.35%	119,887,506	334,981,582,000	16,107,677	1.101268	1.099925	1.100596	2.410774	9.59%
										Average [1986-94]	8.71%
										Average [1986-95]	8.80%

**Chart D5: Calculation of Fisher Ideal Index for Total Company Output**

Year	Revenue Shares			Quantities			Output Indices			Total Company Output Index	Growth
	Local Service	Intrastate Toll and Intrastate Access	Interstate	Number of Local Calls	Intrastate DEMs	Interstate Quantity Index	Laspeyres	Paasche	Fisher Relative		
							A	B	$C=(A*B)^{0.5}$		
1985	49.58%	24.00%	26.42%	310,696,999,600	164,191,177,000	1.000000	1.000000	1.000000	1.000000	1.000000	
1986	49.68%	23.50%	26.83%	315,839,746,231	173,173,536,000	1.052751	1.035272	1.034895	1.035083	1.035083	3.45%
1987	49.68%	24.14%	26.18%	320,735,770,416	183,597,411,000	1.137975	1.043561	1.042639	1.043100	1.079696	4.22%
1988	48.69%	24.98%	26.33%	318,724,184,964	191,904,837,000	1.285462	1.041736	1.039449	1.040592	1.123522	3.98%
1989	49.47%	24.54%	25.99%	330,212,044,704	207,298,177,000	1.365595	1.054001	1.053389	1.053695	1.183850	5.23%
1990	50.16%	24.53%	25.30%	342,403,840,684	217,913,904,000	1.531882	1.062478	1.060759	1.061618	1.256797	5.98%
1991	51.67%	23.41%	24.92%	353,219,571,000	219,713,721,000	1.690127	1.044009	1.042832	1.043420	1.311367	4.25%
1992	52.66%	22.45%	24.89%	365,468,629,000	224,278,538,000	1.793878	1.038080	1.038005	1.038042	1.361254	3.73%
1993	52.87%	22.15%	24.97%	376,995,406,000	227,540,869,000	2.007812	1.049556	1.048164	1.048860	1.427765	4.77%
1994	53.20%	21.36%	25.44%	392,601,075,000	235,362,364,000	2.190425	1.052215	1.052028	1.052121	1.502182	5.08%
1995	55.06%	19.17%	25.76%	409,383,799,000	246,926,539,000	2.410774	1.058829	1.058314	1.058572	1.590167	5.69%
										Average [1986-94]	4.52%
										Average [1986-95]	4.64%

## FCC Staff Estimates

**Chart D6: Labor Input Price and Growth**

RBOC Year	Total Employees A	Total Compensation B	Labor Rate Annual, C = B / A	Labor Price Index (Base = 1985)	Labor Growth %Chg in A
1985	504,113	16,991,572,326	33,706	1.000000	
1986	482,698	16,728,435,454	34,656	1.028192	-4.34%
1987	477,714	16,978,905,847	35,542	1.054474	-1.04%
1988	466,827	17,030,359,791	36,481	1.082336	-2.31%
1989	461,149	16,910,850,694	36,671	1.087974	-1.22%
1990	443,105	17,586,868,921	39,690	1.177541	-3.99%
1991	414,457	17,186,211,200	41,467	1.230255	-6.68%
1992	411,167	17,160,988,000	41,737	1.238279	-0.80%
1993	395,639	17,956,438,000	45,386	1.346528	-3.85%
1994	367,196	17,154,284,000	46,717	1.386018	-7.46%
1995	346,843	16,203,522,000	46,717	1.386024	-5.70%
				Average [1986-94]	-3.52%
				Average [1986-95]	-3.74%

\*Sources:

Column A: ARMIS data for total of full and part-time employees.

Column B: SOCC

## FCC Staff Estimates

**Chart D7: Summary of Capital Adjustments and Average Depreciation**

Year	TPIS.BOY A	Unadj. Additions B	TPIS.EOY C	Retires D=A+B-C	Adjustment Factor E	Adjusted Additions F = B * E	Adjusted EOY TPIS G = A+F-D	Depreciation Accruals H	Adjusted Depreciation Rate I=H/((A+G)/2)
1985	138,879,365	15,001,998	149,061,793	4,819,569	0.8880	13,322,021	147,381,816	10,241,376	7.155%
1986	149,061,793	14,842,725	159,010,189	4,894,328	0.8880	13,180,584	157,348,048	11,826,961	7.720%
1987	159,010,189	14,138,370	167,720,577	5,427,983	0.8880	12,555,105	166,137,312	13,311,655	8.188%
1988	168,505,114	14,284,742	175,860,216	6,929,640	1.0000	14,284,742	175,860,216	13,134,992	7.629%
1989	175,860,216	13,283,569	182,978,381	6,165,404	1.0000	13,283,569	182,978,381	13,420,810	7.480%
1990	182,978,381	14,476,334	187,168,695	10,286,020	1.0000	14,476,334	187,168,695	13,439,933	7.262%
1991	187,168,695	14,527,049	192,034,545	9,661,199	1.0000	14,527,049	192,034,545	13,200,593	6.962%
1992	192,034,545	14,611,866	196,411,915	10,234,496	1.0000	14,611,866	196,411,915	13,337,581	6.867%
1993	196,411,915	14,860,116	203,082,418	8,189,613	1.0000	14,860,116	203,082,418	14,032,782	7.025%
1994	203,082,418	14,717,999	209,325,562	8,474,855	1.0000	14,717,999	209,325,562	14,863,196	7.208%
1995	209,325,562	15,374,568	217,430,207	7,269,923	1.0000	15,374,568	217,430,207	15,358,553	7.198%
Average [1985-95]									7.336%

**Sources:**

Columns A, B, C and H are revised Form M data compiled by the Accounting and Audits Division of the FCC Common Carrier Bureau.  
Column E is derived from Christensen's USTA Revised Study of 1995.

## FCC Staff Estimates

**Chart D8: Construction of Materials Quantity Index**

Year	Materials Price Index (1985=1.00) A	Operating Expense B	Depreciation & Amortization Expense C	Employee Compensation D	Materials Expense E = B + C + D	Materials Quantity Index F = E / A	Materials Quantity Index (1985 = 1.0) G	Materials Quantity Index Growth H
1985	1.0000	40,953,072,435	10,024,710,656	16,991,572,326	13,936,789,453	13,936,789,453	1.000000	
1986	1.0208	42,424,084,849	11,592,001,248	16,728,435,454	14,103,648,147	13,816,310,326	0.991355	-0.87%
1987	1.0354	44,293,127,430	13,316,999,560	16,978,905,847	13,997,222,023	13,519,006,111	0.970023	-2.18%
1988	1.0590	46,809,139,000	13,646,937,000	17,030,359,791	16,131,842,209	15,233,555,068	1.093046	11.94%
1989	1.0985	48,600,813,000	13,860,101,000	16,910,850,694	17,829,861,306	16,230,415,414	1.164573	6.34%
1990	1.1434	49,544,744,000	13,931,515,000	17,586,868,921	18,026,360,079	15,765,836,293	1.131239	-2.90%
1991	1.1693	50,901,049,000	13,499,778,000	17,186,211,200	20,215,059,800	17,288,093,619	1.240465	9.22%
1992	1.1938	50,698,625,000	13,822,882,000	17,160,988,000	19,714,755,000	16,514,721,412	1.184973	-4.58%
1993	1.2057	52,766,635,000	14,244,514,000	17,956,438,000	20,565,683,000	17,056,843,079	1.223872	3.23%
1994	1.2342	55,916,863,000	15,068,058,000	17,154,284,000	23,694,521,000	19,197,642,055	1.377480	11.82%
1995	1.2639	56,831,094,000	15,556,284,000	16,203,522,000	25,071,288,000	19,836,681,477	1.423332	3.27%
						Average		3.53%

Sources: Column A: Derived from BLS data as described in text. 1994 and 1995 values are extrapolated.

Column B: SOCC. 1985-87 Data adjusted by USTA Methodology shown in Chart 8a below.

Column C: SOCC

Column D: ARMIS

**Chart D8a: Adjustments of 1985-87 RBOC Operating Expenses for Accounting Changes**

	USTA Study Operating Expense A	Nonregulated Expense Adjustmt B	Capital/Expense Shift C	Shift Factor D = (A+B+C)/A	RBOC Operating Expense E	Adjusted Operating Exp. F = D * E
1985	46,223,368,251	406,886,403	1,985,079,714	1.05175	38,938,104,053	40,953,072,435
1986	48,113,849,487	471,112,072	1,959,363,711	1.05052	40,384,079,165	42,424,084,849
1987	49,562,282,080	1,089,570,002	1,908,791,665	1.06050	41,766,392,483	44,293,127,430

Sources: Columns A-C: Christensen data from USTA Revised 1995 Study

Column E: SOCC

## FCC Staff Estimates

**Chart D9: Capital Quantity and Price Index Calculations**

Year	Benchmark A	Adjusted Capital Additions B	BEA Composite Asset Price C	Capital Stock Quantity D	Capital Input Quantity E	Capital Input Quantity Growth F	Property Income /w Depreciation G	Capital Rental Price* H	Capital Rental Price Index I (Base = 1985)	Capital Rental Price Index Growth J
1984		n/a		103,903,095						
1985	109,602,959	13,322,021	1.000000	109,602,959	1.000000		23,445,593,794	0.22565	1.00000	
1986		13,180,584	1.013181	114,571,778	1.054857	5.34%	26,792,578,943	0.24445	1.08333	8.00%
1987		12,555,105	1.030871	118,346,112	1.102679	4.43%	27,701,751,800	0.24179	1.07151	-1.10%
1988		14,284,742	1.035999	123,452,811	1.139005	3.24%	26,866,209,000	0.22701	1.00605	-6.30%
1989		13,283,569	1.075241	126,750,564	1.188153	4.22%	25,845,853,000	0.20936	0.92781	-8.10%
1990		14,476,334	1.092233	130,706,243	1.219892	2.64%	25,584,541,000	0.20185	0.89453	-3.65%
1991		14,527,049	1.106013	134,252,460	1.257963	3.07%	24,641,357,000	0.18852	0.83548	-6.83%
1992		14,611,866	1.111942	137,544,780	1.292093	2.68%	26,477,135,000	0.19722	0.87401	4.51%
1993		14,860,116	1.123482	140,681,565	1.323779	2.42%	26,914,823,000	0.19568	0.86719	-0.78%
1994		14,717,999	1.140461	143,266,703	1.353969	2.25%	26,366,385,000	0.18742	0.83058	-4.31%
1995		15,374,568	1.150848	146,116,232	1.378849	1.82%	27,166,096,000	0.18962	0.84033	1.17%
					Average [1986-94]	3.37%			Average [1986-94]	-2.06%
					Average [1986-95]	3.21%			Average [1986-95]	-1.74%

**Notes:**

Column D equals prior year Capital Stock less depreciation (7.336%) plus Column B deflated by Column C.

Column H equals Column G divided by 1000 times prior year Column D.